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SWOT-AHP-TOWS analysis of private investment behavior in the Chinese biogas sector

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ABSTRACT

Biogas is one of the important renewable energy sources, which is expected to significantly contribute not only for the successful achievement of a low carbon transition but also to achieve global climate change policy targets. Private investment is identified as a critical factor for biogas sector to fulfill its expected role. Hence, this paper emphasizes on identifying private stakeholder's investment criteria in order to increase its active involvement for biogas in China. This study focused on banks, insurance companies, pension funds, private equity funds and high network individuals as the primary stakeholders. It applies an SWOT-AHP-TOWS analysis, in which the Strengths, Weaknesses, Opportunities, and Threats (SWOT) of stakeholders are identified and then prioritized by using the analytical hierarchy process (AHP). Finally, the TOWS matrix supports the development of private investment strategies, which serve as a foundation for Chinese policy makers to promote private investments in the biogas sector. The following strategies have been identified as the most important ones: (1) Promoting financial tailored biogas products in terms of volume, interest rate and duration for banks; (2) Permitting insurance companies and pension funds directly investing into biogas equity; (3) Encouraging public-private partnerships and (4) Improving project cooperation by introducing professional guidance.

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1. Introduction

China has committed itself to further promote small- and large-scale biogas projects to become less reliant on fossil fuels (Rupf et al., 2015; Song et al., 2014). Biogas is not just a critical tool to reduce carbon emissions but also to provide rural areas with energy, especially for remote areas without connection to the national grid (Cong et al., 2017; Kettunen et al., 2017; Rubio-romero et al., 2013; The World Bank, 2014). The Chinese government is also encouraging the establishment of mid- and large-scale biogas plants by offering several subsidy schemes (He et al., 2016; Song et al., 2014; Wang et al., 2014).

Governments support, in the form of subsidies, is mainly directed towards large-scale biogas plants to achieve scale effects. Investment costs of large-scale biogas plants can range between 1 million and 10 million U.S. dollars (Hojnacki et al., 2011).

The Chinese government continuously supported the development of biogas in the form of subsidies, tax exemptions and low interest loans. These support mechanisms are demonstrated in Table 1(Hallie and Josephine, 2017; KPMG, 2015; Sun et al., 2014; Van Eynde et al., 2014). These governmental support programs illustrate that the Chinese government spending on biogas programs is tremendously high.

In terms of the existing feed-in tariffs in China, the Chinese government delegated the determination of the feed-in tariffs for biogas to the provinces. As an example, Table 2 illustrates the feed-in tariffs for Jilin province from 2015 to 2020 (Provincial Government of JiLin (2017)).

Nevertheless, in the future, the Chinese government will cut down on large investment grants for establishing large-scale biogas plants, so that private funding has to be increased (China's Ministry of Agriculture (2013); GIZ, 2012).

After having demonstrated the current financial support programs, the Chinese government also established several legislative guidelines that promote the development of Biogas in China. Table 3 outlines these guidelines and illustrates their major goals:

Financial instruments, e.g., loans and guarantees, are rarely used for rural household biogas digesters in China (Xia, 2014). One possible reason for this phenomenon is that many documents are required to receive the necessary funds. Also, there is a lack of

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Table 1
Chinese legislation for Biogas.

Year	Name of program	Goals	Issuer	Form
2001	Administration Method of Small-scale Public Facilities Funds for Rural areas	Trial subsidy standard with focus of western and central China, each county received no more than 0.6 million RMB per year	MOF	Subsidy
2003	Administration Method of National Bonds for Construction of Rural Biogas	Cover more counties than the previous subsidy program from 2001	MOA	Subsidy
2006	National Rural Biogas Construction Plan (2006–2010)	Further clarified administrative methods of rural biogas subsidization (volume of biogas digesters increased by 16.1%)	MOA	Subsidy
2009	Construction of rural biogas digesters	1500RMB per household in northeast and western areas, 1200RMB in central areas and 1000RMB in eastern areas	NDRC/MOA	Subsidy
2010	Revised Renewable Energy Law	Established the renewable energy fund to provide biogas subsidies	NDRC	Subsidy
2010	Low or zero interest loan programs for biogas	Loans without interest for medium and large-scale biogas projects	/	Low interest
2014	Corporate Income Tax (CIT)	A reduced CIT rate of 15% is granted to qualified advanced and new technology enterprises	NDRC	Tax exemptions
2014–2017	Enterprises operating CDM projects	A 3-year exemption of the CIT is followed by a 50% reduction for another 3 years of the standard CIT rate derived from the CDM project	NDRC	Tax exemptions
2017	Promotion of biogas	Recycling programs by 2020 in 200 major counties that have livestock farms/provide subsidies to farmers to treat manure and animal waste through biogas plants	MOA	Subsidy

Table 2
Major biogas goals.

Policy	Major goals for biogas
10th five year plan	Build 1000 biogas facilities/Ability of producing 600 million cubic meters biogas per year
11th five year plan	Over 40 millon families shall use biogas/Installed capacity will reach 1 million KW
Medium and long-term Energy Development Strategy (2004)	Introduction of financial incentives to further boost the development of biogas in rural China as well as for the development of large-scale biogas projects
12th five year plan	Exploitation of 14 million cubic meters of biogas/ Over 50 million families shall use biogas
13th five year plan	0.5 GW from biogas (an increase of 66% in comparison to the goals of the 12th year plan)

Table 3
Feed-in tariffs for Jilin province.

Feed-in tariffs for JiLin province		
Year	Subsidy standard	Feed-in tariff
2015	0.2215	0.5605
2016	0.217	0.556
2017	0.2127	0.5517
2018	0.2083	0.5474
2019	0.2043	0.5433
2020	0.2002	0.5392

innovative financial products like for instance, private equity investment, which creates a funding gap for biogas projects (Gabriel, 2016). The biogas sector requires further adequate funding structures because there are still various obstacles in place (Surendra et al., 2014; van Groenendaal and Wang, 2010). As a result of this, investors in China rarely engage in biogas projects as private funding mechanisms are far from being fully developed (Xia, 2014).

To alter this situation and achieve the goal of a total biogas production of 44 billion cubic meters by 2020 (National Development and Reform Commission, 2007), more private investments into the biogas sector are required (Gu et al., 2016; Gong and Li, 2016; Wang and Liu, 2016). This is obvious since an increase in private investment will reduce local government debt and make the biogas sector more efficient (An et al., 2015; Li et al., 2017; Monk and Provaggi, 2012; Reuters, 2013).

In the 13th five year plan, the goals for 2020 in terms of biogas have been determined. For instance, the amount of small and midscale biogas plants should be increased to 128,976 in total.

Table 4
Chinese biogas goals and achievements.

Index	Unit	End of 2015	Goals 2020
Small-scale &Mid-scale	Plants	103,476	128,976
Large-scale	Plants	6972	10,122
Rural household biogas	10 thousand households	4193	4304
Total biogas production	100 million cubic meter	158	207
Biogas fertilizer production	10 thousand tons	7100	9751
Agricultural waste disposal ability	10 thousand tons/year	200,000	208,047
Power generation from biogas	GW	0.3	0.5
Carbon dioxide emission reduction	10 thousand tons/year	2860	4622
COD reductions	10 thousand tons/year	1209	1581

Furthermore, large scale biogas plants are supposed to increase from 6972 to 10,122 from the end of 2015 until 2020. In addition to that, carbon dioxide emissions shall be reduced through the usage of biogas until 2020. These and other goals and achievements in terms of biogas are illustrated in Table 4 (IEA, 2016; National Development and Reform Commission, 2017):

To promote private investment, Chinese Premier Li, endorsed public-private partnerships (PPP) in a State Council executive meeting in 2014 and introduced new incentives to support public-private partnerships on July 07th, 2016 (China's State Council, 2016). In 2013, public-private partnerships became a popular model of the Chinese government to engage private players in several projects (Xinhua, 2016). For instance, in §18 of its guidelines for innovative investment and finance mechanisms, the Chinese State Council endorses private investments into renewable energy including biogas (China's State Council, 2014). In §29 PPP is mentioned as one of the possible forms of private investment. Finally, in §34 the State Council provides certain incentives for private investments like subsidies or low interest for loans.

To achieve the environmental goals of China, funding of at least 2 trillion RMB of funding is required, of which about 85% will originate from the private sector (Wong, 2016; Qi and Li, 2017). Hence, the Chinese government is currently contemplating to develop supportive policies based on private investors preferences to attract private investment (China's State Council, 2017, 2016).

Current academic literature is lacking an in-depth analysis of private sector's investment preferences for the biogas sector to

develop appropriate policies (Jiang et al., 2017). Hence, this paper's general aim is to provide a decisive analysis of the major private investor's investment preferences in the biogas sector in China. More specific research goals are (1) identifying the strengths, weaknesses, opportunities, and threats of the current private investors; (2) determining the importance of these factors for investment in biogas projects and (3) developing policies to encourage future private investment for Chinese policy makers. This paper's scientific contribution is to close the existing academic knowledge gap on private stakeholder's investment preferences in the Chinese biogas sector, through a combined application of the SWOT-AHP-TOWS analysis, which is based on the first-hand interview data collected in 525 interviews.

Past research on stakeholder preferences and policy development has indicated that there are several analytical tools, which can assist in policy formulation. One famous model is the so-called analytical hierarchy process (AHP). In particular, for examples, in the energy performance contracting field to measure investment risks (Garbuzova-Schlifter and Madlener, 2016; Sambasivan and Fei, 2008; Tseng et al., 2009) and in the case of offshore wind farms to identify investor interests (Chaouachi et al., 2017). As illustrated in Table 5, AHP has been widely applied to support a company's decision-making processes to ensure the development of appropriate strategies (Lee et al., 2008, 2007; Sadeghi and Ameli, 2012; Sennaroglu and Hariz, 2017).

In addition to that, there have been several SWOT analysis conducted on stakeholder opinion but also on existing technology and policy development. For instance, SWOT has been applied to evaluate energy technology in Sub-Saharan Africa or to analyze the future ASEAN energy mix. While most of the existing literature either reviewed technologies, policies or renewable energy projects with focus on wind and solar power, private investment preferences in biogas projects have not experienced any detailed analysis by applying a SWOT analysis.

SWOT and AHP/ANP has been used for instance in the manufacturing sector (Görener et al., 2012; Vahidi et al., 2018). This combination has also been applied in the energy sector (Brudermann et al., 2015; Eslamipoor and Sepehriar, 2014; Imran, 2018; Okello et al., 2014; Thanki et al., 2016) or in other sectors like the telecom industry (Mehmood et al., 2014), mining (Shahba et al., 2017) and the steel scrap sector (Shahabi et al., 2014). Hence, this method proved to be very useful to examine the current environment of a company or other organization and support the decision-making process in more detail as before (Posch et al., 2015; Rachid and El Fadel, 2013; Szulecka and Monges Zalazar, 2017; Wang et al., 2014). Especially for stakeholder's investment preference analysis, SWOT-AHP/ANP proved to be very effective (Zavadskas et al., 2011; Zorpas et al., 2017). Nevertheless, the disadvantage of this method is that it does not enable to develop policies based on its results.

The SWOT-AHP-TOWS analysis is a further combination of analysis tools to further improve the decision-making process and also to develop policies based on the results from SWOT and AHP. It is one of very few models that enable the integration of analysis, identifying the priorities of individual factors and develop the adequate policies. For instance, SWOT-AHP-TOWS has been applied in the biodiesel and bioethanol sector in Thailand to develop decisive policies (Chanthawong and Dhakal, 2016). Furthermore, it has been implemented in other sectors like electronics and the airline business (Şeker and Özgürler, 2012; Sevkli et al., 2012). It has also been applied in watershed management in Turkey but also in Finland identifying investment alternatives and developing policies accordingly (Kajanus et al., 2012; Yavuz and Baycan, 2013).

Hence, SWOT-AHP-TOWS is suitable for this study as it enables the identification of private investors investment preferences and the development of appropriate policy strategies. There are many stakeholders that can be referred to as private investor's (Demirgu and Maksimovic, 1999; Froot and Stein, 1998). This study examines only those stakeholders with the highest likelihood to be able to invest into future biogas projects. The most influential and skilled private investors are banks, insurance companies, pension funds, private equity funds and high network individuals (Crifo et al., 2015; Díez-Esteban et al., 2016; Domanski and Heath, 2007; Forbes, 2015). All of these stakeholders not only have the required volume but also have the expertise to conduct investments into biogas projects (Buchner and Wagner, 2017; Eurosif, 2012).

The remainder of this paper is organized as follows. Section 2 describes the methodology of this study. Section 3 shows the results of a SWOT-AHP-TOWS analysis and Section 4 discusses policy implications. Section 5 is the conclusion.

Table 5
Literature review on SWOT-AHP and their relation to this study.

Nr.	Method	Topic	Relation with this research topic	Country	Author
1	AHP	Energy performance contracting	Measuring investment risks	Russia	(Garbuzova-Schlifter and Madlener, 2016)
2	AHP	Offshore wind farms	Identify investors interests	Baltic	(Chaouachi et al., 2017)
3	AHP	Energy subsidy in subsectors	Decision making for subsidy models	Iran	(Sadeghi and Ameli, 2012)
4	AHP	Hydrogen energy	Decision-making model for policy makers	Korea	(Lee et al., 2008)
5	AHP	National energy efficiency	Development of national policy strategies	Korea	(Lee et al., 2007)
6	SWOT-AHP	Forest plantations	Constraining factors for investment	Paraguay	(Szulecka and Monges Zalazar, 2017)
7	SWOT-AHP	Mine waste management	Tactical investment on mining activities	Iran	(Shahba et al., 2017)
8	SWOT-AHP	Agricultural biogas plants	Financial impact on agricultural biogas	Austria	(Brudermann et al., 2015)
9	SWOT-AHP	Environment improvement	Decision-making for reducing air pollution	Iran	(Eslamipoor and Sepehriar, 2014)
10	SWOT-AHP	Manufacturing firm	Determining strategy alternatives	Turkey	(Gorener et al., 2012)
11	SWOT-AHP	Telecom industry	Developing new product strategies	Italy	(Mehmood et al., 2014)
12	SWOT-AHP	Strategic environmental assessment	Analyzing opportunities within the market	MENA	(Rachid and El Fadel, 2013)
13	SWOT-AHP	Bioenergy	Evaluation of stakeholder preferences	Uganda	(Okello et al., 2014)
14	SWOT-AHP	Enterprise management	Analysis of stakeholder interests	Lithuania	(Zavadskas et al., 2011)
15	SWOT-AHP	Worldwide Express Mail Service	Develop effective financial strategies	China	(Wang et al., 2014)
16	SWOT-ANP	Steel scrap industry	Evaluation of power plant investments	Iran	(Shahabi et al., 2014)
17	SWOT-ANP-TOWS	Airline industry	Strategic decisions for airline industry	Turkey	(Sevkli et al., 2012)
18	SWOT-AHP-TOWS	Biodiesel and bioethanol policy	Analyzing stakeholder perceptions	Thailand	(Chanthawong and Dhakal, 2016)
19	SWOT-AHP-TOWS	Strategic natural resources	Identifying investment alternatives	Finland	(Kajanus et al., 2012)
20	SWOT-AHP-TOWS	Consumer electronics firm	Support decision making for new products	Turkey	(Seker and Özgurler, 2012)
21	SWOT-AHP-TOWS	Watershed management	Measuring stakeholder preferences	Turkey	(Yavuz and Baycan, 2013)

2. Methodology

The methodology consists out of a theoretical/methodological approach as well as data collection and implementation. This is based on the three respective methods.

2.1. SWOT analysis

SWOT analysis is a well-known situational analytical tool, which has been applied in many organizations to boost their strategic decision-making process (Helms and Nixon, 2010). SWOT is an acronym, standing for strengths, weaknesses, opportunities, and threats, which are characterizing an institution's internal as well as external environment (Harvard Business School, 2006; Hill and Westbrook, 1997). This analysis tool is particularly tailored for companies, which intend to invest or acquire a new asset as it helps them in the decision-making process (Gomer and Hille, 2012).

With regard to the data collection, this study firstly determined the most important private investor stakeholders based on literature review:(1) Insurance companies, which are seeking diversification through the investment into several asset classes; (2) Banks, which are the main funding institution when it comes to the Chinese biogas sector; (3) Pension funds, which usually have a tremendous volume of funds available, that can be invested into biogas projects. Furthermore, they have a longer investment duration in comparison to other private investors; (4) Private equity investors, which usually have a higher risk but also higher return investment profile and finally; (5) High network individuals, commonly referred to an individual person with a net worth of usually higher than 10 million Dollars, who are seeking particular investment opportunities based on their individual preferences.

Second, 50 personal interviews per stakeholder group have been conducted, which adds up to a total of 250 interviews. As this is a pilot study of private investment preferences in the Chinese biogas sector, accidental sampling has been be applied to collect data, as it is most suitable for pilot projects. Therefore, mostly larger companies, mainly based in Beijing and Shanghai were contacted through their Human Resources (HR) department or online through their websites. In the case of private individuals, the Tsinghua alumina network was establishing the contact. Certain criteria for the interview have been pre-determined to obtain adequate results: (a) at least 5 years of working experience in the respective industry; (b) knowledge in the field of biogas; (c) holding a relevant position in the individual organization within China to ensure that questions are appropriately answered and; (d) being available for all three interview processes. Based on this, detailed questions were asked to identify the SWOT factors of which only those are chosen, which have been mentioned by more than 40% of all stakeholders. Fig. 1 demonstrates the education level and working experience of the interviews:

2.2. AHP analysis

The SWOT analysis has been supplemented by the AHP analysis. This is due to the fact that it quantifies each factor based on its priority for the respective organization (Kim et al., 2017; Saaty, 1986). To determine the effects of these policies on investment, an analytical hierarchy process (AHP) has been performed and weighted values assigned through interviews with investor representatives. This method has proven its value in several previous studies (Geng et al., 2017; Kurttila et al., 2000). Each factor of one category will be compared to the other, resulting in a cross analysis of each stakeholder's preferential investment criteria for biogas projects (Saaty, 1977). Pairwise comparisons have been conducted as illustrated in Table 6:

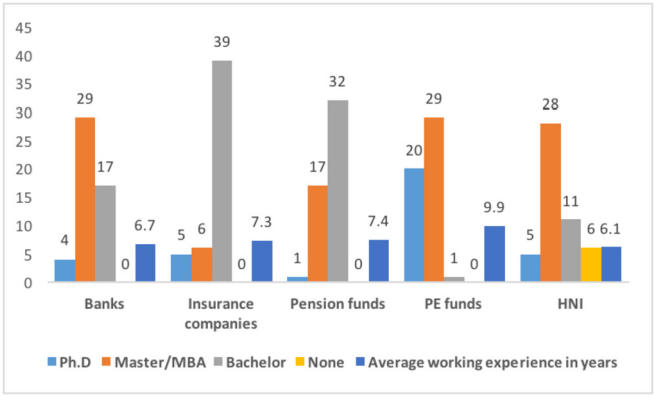

Fig. 1. Education level and work experience of the interviewees.

Table 6
Pairwise comparison for this study.

Factor	Factor weighting score		Factor
	More importance than	equal	More importance than
X_1	9 8 7 6 5 4 3 2	1	2 3 4 5 6 7 8 9 X_2
X_2	9 8 7 6 5 4 3 2	1	2 3 4 5 6 7 8 9 X_3
X_3	9 8 7 6 5 4 3 2	1	2 3 4 5 6 7 8 9 X_1

Denote the relative weight of factor X_i over factor X_j in an individual SWOT group as a_{ij}. By pairwise comparison, the values of a_{ij} and a pairwise comparison matrix A can be obtained, in which:

$$A = (a_{ij}) = \begin{bmatrix} X_1/X_1 & X_1/X_2 & \cdots & X_1/X_n \\ X_2/X_1 & X_2/X_2 & \cdots & X_2/X_n \\ \vdots & \vdots & \vdots & \vdots \\ X_n/X_1 & X_n/X_2 & \cdots & X_n/X_n \end{bmatrix} \quad (1)$$

Denote the relative priority of each factor in a particular SWOT group by $W = (\omega_1, \omega_2, \ldots, \omega_n)$ (Ahmad and Tahar, 2014). W can be determined by calculating the normalized eigenvector of A corresponding to the A 's Eigen-value λ_m, i.e.,

$$AW = \lambda_m W \quad (2)$$

Besides, the consistency of matrix A has to be taken into account. A is consistent if

$$a_{ij} = a_{ik} \cdot a_{kj}, \ \forall i, j, \ k = 1, 2, \ldots, n. \quad (3)$$

If A is not consistent, a consistency index (CI) analysis can be completed to determine the consistency ratio (CR). This is done by the following equation:

$$CI = (\lambda_m - \ n)/(n - 1)$$

$$CR = \frac{CI}{RI} \quad (4)$$

Where RI is a random index value. The closer the CI and CR values are to 0 the more consistent and reasonable they are. If $CR \leq 0.1$, the consistency of A is acceptable (Darshini et al., 2013).

In order to conduct the AHP analysis, a second interview was conducted with the same interviewees as survey one, but this time, the interviewees were asked to prioritize the factors within each category of the SWOT analysis based on the most crucial factors identified per category in the first interview. After having determined the stakeholder's priorities for each of the four factors of SWOT, local and global priorities, which illustrate the relative

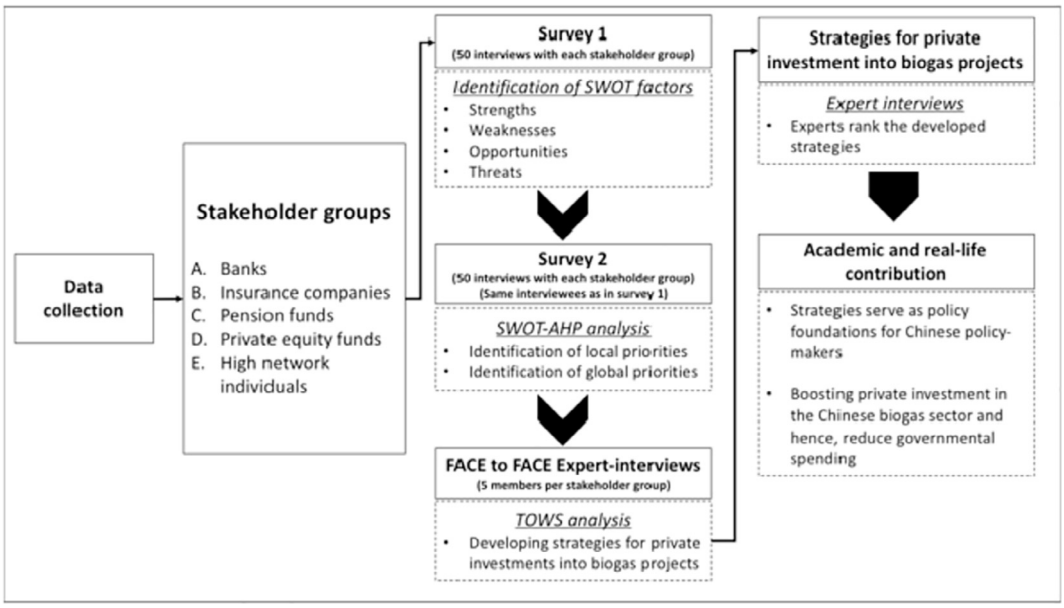

Fig. 2. Data collection and implementation framework of this study.

importance of each of the factors to each other within the same group (local priorities) and respectively the relative importance of each factor within the overall matrix (global priorities), have been calculated. Finally, based on the previous formulas, the consistency ratios have been calculated to determine the soundness of the data.

2.3. TOWS analysis

The TOWS analysis has been widely applied to identify strategies based on a previous conducted SWOT and AHP analysis. Hence, according to the specific TOWS matrix, strategies can be developed, on the basis of the identified strengths, weaknesses, opportunities and threats (Alpar, 2007; Audenhove, 2007; Baker and Edwards, 2012). In fact, these strategies are created by maximizing the strengths and opportunities as well as minimizing the weaknesses and threats of the respective stakeholders. In particular, they consider the results of group, local and global priority results. Expert interviews are a useful tool to conduct discussions among small groups of people to achieve a maximum of high quality discussion and outcome (Bogner et al., 2009; Littig, 2013). Therefore, this method should be applied to collect information on a TOWS analysis.

Based on these results from the AHP analysis, private investment policy strategies were developed by applying the TOWS analysis. This was done in the form of expert interviews, in which a team of 5 industry experts per stakeholder group, face to face with the interviewer, developed private investment strategies. The face to face interviewees also have been randomly selected from the larger interviewee group, which ensures the interviewees professional qualification and avoid bias in the research outcome. Furthermore, the subjective aspects of determining the coefficients have been reduced to a minimum by, first, a high sample size (conducting 250 interviews). Second, subjectivity has been limited by only selecting factors that have been mentioned by over 40% of the interviewees. Third, the pairwise comparison of the AHP analysis further reduces subjectivity as the calculated consistency ratios clearly illustrate inconsistencies.

After the strategies had been developed, the experts were asked to rank these strategies based on their individual perspective on the strategies importance to attract private investments into the Chinese biogas sector. The ranking is displayed in the form of an overall mean of the interviewed experts opinion towards the strategies. Therefore, only the most crucial strategy for each private investor group has been considered as a suggestion for policy makers. The process of ranking and selecting one strategy for one stakeholder group also involves a feasibility discussion among the respective experts. The data collection and implementation process are also illustrated in Fig. 2:

3. Results

3.1. SWOT analysis and prioritization of factors for policy development through SWOT-AHP analysis

3.1.1. Banks

According to results of the SWOT-AHP analysis, the main strength of banks is comparatively low capital costs, which ultimately makes it easy to achieve a break-even on the biogas investment. Furthermore, high-risk aversion is regarded as the major weakness as banks usually do not invest by from their balance sheets into assets but rather through other investment vehicles as it can be seen in Fig. 3. Concerning opportunities for investments into biogas in China, the highest score was preferential taxes, while also a large share of interviewees regards the boost of their public image as the main opportunity. The major threat is considered to be the limited investment funds available to banks for investments into biogas projects.

3.1.2. Insurance companies

Insurance companies' major strength is, according to the SWOT-AHP analysis, the high level of liquidity as well as the high volume of funds available for investment into biogas projects. Fig. 4 illustrates that the major weakness is viewed as the non-sufficient research capabilities of insurance companies as, without adequate knowledge on biogas investments, risks can not be accounted appropriately. Non-dependency on short-term liquidity has received the highest score among opportunities as this makes insurances less vulnerable to market fluctuations. The low

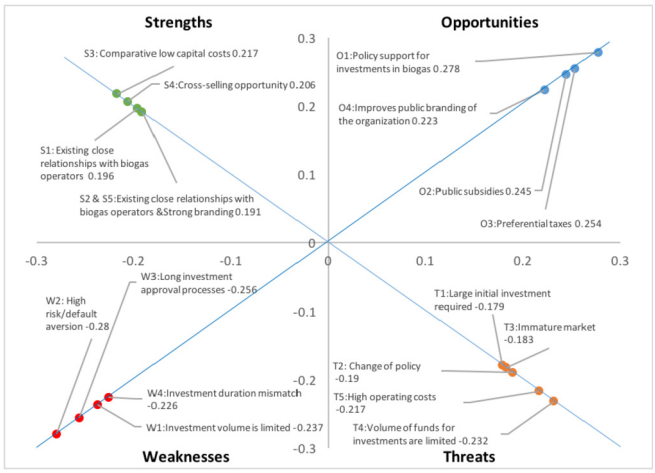
Strengths
Opportunities
S3: Comparative low capital costs 0.217
S4:Cross-selling opportunity 0.206
S1: Existing close relationships with biogas operators 0.196
S2 & S5:Existing close relationships with biogas operators &Strong branding 0.191
O1:Policy support for investments in biogas 0.278
O4:Improves public branding of the organization 0.223
O2:Public subsidies 0.245
O3:Preferential taxes 0.254
W3:Long investment approval processes -0.256
W2: High risk/default aversion -0.28
W4:Investment duration mismatch -0.226
W1:Investment volume is limited -0.237
T1:Large initial investment required -0.179
T3:Immature market -0.183
T2: Change of policy -0.19
T5:High operating costs -0.217
T4:Volume of funds for investments are limited -0.232
Weaknesses
Threats

Fig. 3. SWOT-AHP analysis of banks.

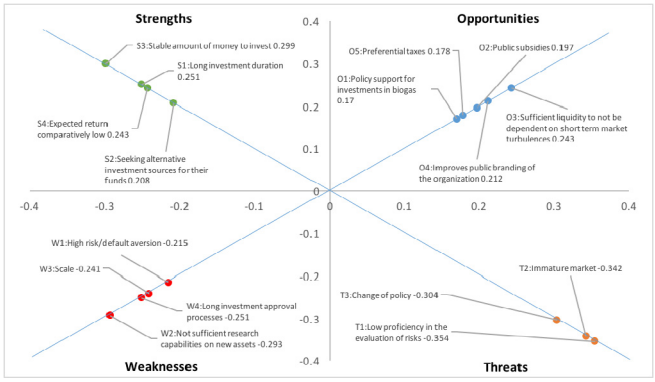
Strengths
Opportunities
S3:Stable amount of money to invest 0.299
S1:Long investment duration 0.251
S4:Expected return comparatively low 0.243
S2:Seeking alternative investment sources for their funds 0.208
O5:Preferential taxes 0.178
O2:Public subsidies 0.197
O1:Policy support for investments in biogas 0.17
O3:Sufficient liquidity to not be dependent on short term market turbulences 0.243
O4:Improves public branding of the organization 0.212
W1:High risk/default aversion -0.215
W3:Scale -0.241
W4:Long investment approval processes -0.251
W2:Not sufficient research capabilities on new assets -0.293
T2:Immature market -0.342
T3:Change of policy -0.304
T1:Low proficiency in the evaluation of risks -0.354
Weaknesses
Threats

Fig. 4. SWOT-AHP analysis of insurance companies.

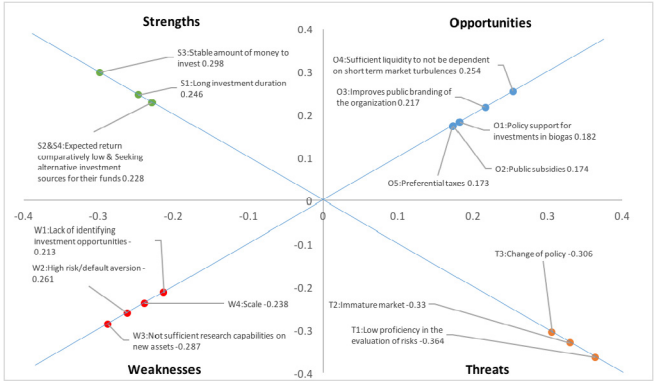
Strengths
Opportunities
S3:Stable amount of money to invest 0.298
S1:Long investment duration 0.246
S2&S4:Expected return comparatively low & Seeking alternative investment sources for their funds 0.228
O4:Sufficient liquidity to not be dependent on short term market turbulences 0.254
O3:Improves public branding of the organization 0.217
O1:Policy support for investments in biogas 0.182
O2:Public subsidies 0.174
O5:Preferential taxes 0.173
W1:Lack of identifying investment opportunities -0.213
W2:High risk/default aversion -0.261
W4:Scale -0.238
W3:Not sufficient research capabilities on new assets -0.287
T3:Change of policy -0.306
T2:Immature market -0.33
T1:Low proficiency in the evaluation of risks -0.364
Weaknesses
Threats

Fig. 5. SWOT-AHP analysis of pension funds.

proficiency in evaluating risks has been rated as the major threat because most insurances don't have the resources to conduct in-depth research on the Chinese biogas sector.

3.1.3. Pension funds

SWOT-AHP analysis among pension funds concluded that a stable volume of available funding is regarded as the major strength as pension funds usually hold plenty of funds for a long time for their clients. Moreover, the lack of research capabilities received the highest scores as the major weakness as the main business of

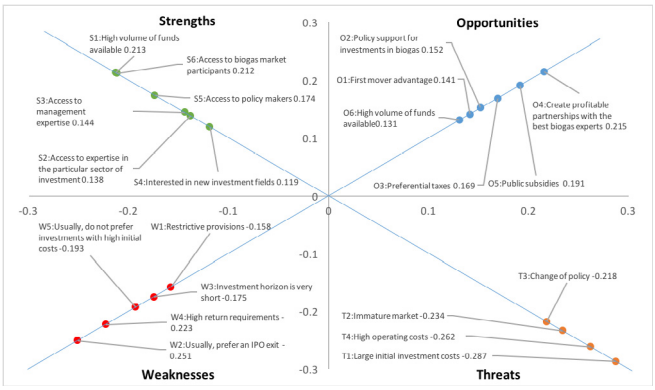
Strengths
Opportunities
S1:High volume of funds available 0.213
S6:Access to biogas market participants 0.212
S3:Access to management expertise 0.144
S5:Access to policy makers 0.174
S2:Access to expertise in the particular sector of investment 0.138
S4:Interested in new investment fields 0.119
O2:Policy support for investments in biogas 0.152
O1:First mover advantage 0.141
O6:High volume of funds available 0.131
O4:Create profitable partnerships with the best biogas experts 0.215
O3:Preferential taxes 0.169
O5:Public subsidies 0.191
W5:Usually, do not prefer investments with high initial costs -0.193
W1:Restrictive provisions -0.158
W3:Investment horizon is very short -0.175
W4:High return requirements - 0.223
W2:Usually, prefer an IPO exit - 0.251
T3:Change of policy -0.218
T2:Immature market -0.234
T4:High operating costs -0.262
T1:Large initial investment costs -0.287
Weaknesses
Threats

Fig. 6. SWOT-AHP analysis of PE funds.

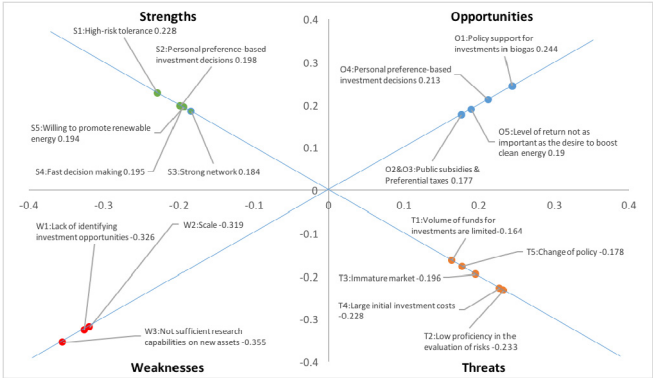
Strengths
Opportunities
S1:High-risk tolerance 0.228
S2:Personal preference based investment decisions 0.198
S5:Willing to promote renewable energy 0.194
S4:Fast decision making 0.195
S3:Strong network 0.184
O1:Policy support for investments in biogas 0.244
O4:Personal preference-based investment decisions 0.213
O5:Level of return not as important as the desire to boost clean energy 0.19
O2&O3:Public subsidies & Preferential taxes 0.177
W1:Lack of identifying investment opportunities -0.326
W2:Scale -0.319
W3:Not sufficient research capabilities on new assets -0.355
T1:Volume of funds for investments are limited -0.164
T5:Change of policy -0.178
T3:Immature market -0.196
T4:Large initial investment costs -0.228
T2:Low proficiency in the evaluation of risks -0.233
Weaknesses
Threats

Fig. 7. SWOT-AHP analysis of HNI's.

pension funds is not to conduct high-risk investments but rather invest its clients deposit into very save asset classes like government bonds as it is illustrated in Fig. 5. Attracting new customers are viewed as the major opportunity as pension funds might are likely to gain new customers based on their renewable energy investment, while the low proficiency of evaluating risks is rated as a major threat due to not having profound knowledge on Chinese biogas projects.

3.1.4. PE funds

According to the prioritization among PE funds, their major strength is that they hold large amounts of funds for investments which is required for large-scale biogas projects. Moreover, the access to biogas operators and hence, the resulting knowledge about the biogas industry was regarded as very important. High return expectations are viewed as the major weakness as it is difficult to achieve a return from 20% to 30% per annum in that industry. Concerning the opportunities, policy support is perceived as the most crucial factor for investments into biogas as this guarantees stable cash inflows. Finally, the large initial investment costs (construction costs) in the biogas sector are viewed as the main threat for PE funds as this diminishes the expected return as demonstrated in Fig. 6.

3.1.5. High network individuals

As demonstrated in Fig. 7, the high-risk tolerance has been rated as a major strength of high network individuals as they usually use their surplus funds for high-risk investments. Lacking adequate risk assessment tools in new investment fields are perceived as the major threat as even with a high-risk tolerance, investment

Table 7
Summary of SWOT-AHP scores based on stakeholder groups and group priorities.

	Banks	Insurance companies	Pension funds	PE funds	HNI
S	0.219	0.234	0.234	0.261	0.233
W	0.255	0.216	0.208	**0.286**	**0.282**
O	0.243	**0.290**	**0.298**	0.215	0.218
T	**0.283**	0.260	0.261	0.238	0.266
Group priorities/within SWOT group					
S1	0.196	0.251	0.246	**0.213**	**0.228**
S2	0.191	0.208	0.228	0.138	0.198
S3	**0.217**	**0.299**	**0.298**	0.144	0.184
S4	0.206	0.243	0.228	0.119	0.195
S5	0.191	–	–	0.174	0.194
S6	–	–	–	0.212	–
W1	0.237	0.215	0.213	0.158	0.326
W2	**0.280**	**0.293**	0.261	**0.251**	**0.355**
W3	0.256	0.241	**0.287**	0.175	0.319
W4	0.226	0.251	0.238	0.223	
W5				0.193	
O1	**0.278**	0.170	0.182	0.141	**0.244**
O2	0.245	0.197	0.174	0.152	0.177
O3	0.254	**0.243**	0.217	0.169	0.177
O4	0.223	0.212	**0.254**	**0.215**	0.213
O5	–	0.178	0.173	0.191	0.190
O6	–	–	–	0.131	–
T1	0.179	**0.354**	**0.364**	**0.287**	0.164
T2	0.190	0.342	0.330	0.234	**0.233**
T3	0.183	0.304	0.306	0.218	0.196
T4	**0.232**	–	–	0.262	0.228
T5	0.217	–	–	–	0.178

The bold numbers indicate the most significant factor's share of supports received from the interviews

decisions should be made based on comprehensive understanding of the biogas sector. The major opportunity is policy support for investments into biogas in China as well as the personal preferences of the asset class which might not be related to the level of returns. For instance, a wealthy person might invest because he believes that the development of biogas plays a crucial role for the future of the country. The major threat is, according to SWOT-AHP analysis, the inability to estimate the risks of investments into biogas as resources are not as vast as in private equity funds.

Table 9
Group comparisons.

	Group comparison of SWOT group (%)	Within group comparisons (%)			
		S (%)	W (%)	O (%)	T (%)
Banks	0.18%	1.13%	0.07%	0.14%	0.06%
Insurance	0.98%	4.42%	2.44%	1.80%	2.30%
Pension fund	0.11%	0.32%	0.49%	0.06%	0.23%
Pe fund	0.05%	0.21%	0.23%	0.06%	0.01%
HNI	0.05%	0.40%	0.18%	0.82%	0.38%

Further information on the specific SWOT factors as well as the AHP analysis are displayed within the Appendix.

3.1.6. Results of group-, local- and global-priorities

The results of the AHP analysis for the previously mentioned SWOT factors are illustrated in Table 7. Furthermore, the group priorities have been calculated in the first part of the mentioned table which reflect, that the priority for banks are clearly the threats with an overall rate of 28%, while insurance companies and pension funds put their priority on opportunities. PE funds and HNI have their highest priority on weaknesses.

According to Table 8, the calculation of local priorities demonstrates that certain factors have a higher importance in comparison to others with the same group. Furthermore, the global priorities display a tremendous significance among the overall comparison of all analyzed factors. These results have been considered in the following step for the development of the respective TOWS matrix.

3.1.7. Results of the consistency ratio analysis

According to Table 9, the consistency ratio for all pairwise comparisons among the following stakeholder groups was below 0,1. In fact, the within-group consistency ratio was for most stakeholder groups below one percent. Only for the stakeholder group "insurance companies" as well as for the strengths section of "banks" the consistency ratio was higher than 0,1. Finally, the consistency ratio for group-comparisons was also lower than the barrier of 0,1 which illustrates that the obtained data is sound. Furthermore, the acceptance of only factors which have been chosen by more then 40% reduces the effort for interviewees to

Table 8
Local and Global priorities.

Priority	Banks		Insurances		Pension funds		PE funds		HNI	
	Local	Global	Local	Global	Local	Global	Local	Global	Local	Global
S1	0.2	0.04	0.25	0.06	0.25	0.06	0.21	0.06	0.23	0.05
S2	0.19	0.04	0.21	0.05	0.23	0.05	0.14	0.04	0.2	0.05
S3	0.22	0.05	0.3	0.07	0.3	0.07	0.14	0.04	0.18	0.04
S4	0.21	0.05	0.24	0.05	0.23	0.05	0.12	0.03	0.2	0.05
S5	0.19	0.04					0.17	0.05	0.19	0.05
S6							0.21	0.06		
W1	0.24	0.06	0.22	0.05	0.21	0.04	0.16	0.05	0.33	0.09
W2	0.28	0.07	0.29	0.06	0.26	0.05	0.25	0.07	0.35	0.1
W3	0.26	0.07	0.24	0.05	0.29	0.06	0.17	0.05	0.32	0.09
W4	0.23	0.06	0.25	0.05	0.24	0.05	0.22	0.06		
W5							0.19	0.06		
O1	0.28	0.07	0.17	0.05	0.18	0.05	0.14	0.03	0.24	0.05
O2	0.25	0.06	0.2	0.06	0.17	0.05	0.15	0.03	0.18	0.04
O3	0.25	0.06	0.24	0.07	0.22	0.06	0.17	0.04	0.18	0.04
O4	0.22	0.05	0.21	0.06	0.25	0.08	0.22	0.05	0.21	0.05
O5			0.18	0.05	0.17	0.05	0.19	0.04	0.19	0.04
O6							0.13	0.03		
T1	0.18	0.05	0.35	0.09	0.36	0.09	0.29	0.07	0.16	0.04
T2	0.19	0.05	0.34	0.09	0.33	0.09	0.23	0.06	0.23	0.06
T3	0.18	0.05	0.3	0.08	0.31	0.08	0.22	0.05	0.2	0.05
T4	0.23	0.07					0.26	0.06	0.23	0.06
T5	0.22	0.06							0.18	0.05

participate in the pairwise comparison analysis and hence, reduce the likelihood of arbitrary evaluations of the interviewees.

3.2. Policy implications of SWOT-AHP applying TOWS analysis

This part of the research paper develops private investment strategies, to encourage private investor's engagement in the Chinese biogas sector. These private investment strategies serve as policy foundations and were identified through expert interviews with 5 participants per stakeholder group. The strategies are as follows:

3.2.1. Banks

A. Promoting biogas funding products concerning volume, interest rate and duration (SO strategy): Banks have the resources to design tailored financial products for the biogas industry, which are currently only existing to a very limited degree. According to the expert interviews, the creation of financial tailored products involves three major areas. First, the volume of loans provided to biogas investors needs to be according to the respective biogas project. For instance, large biogas plants on an average can range between 1 million and 10 million dollars (Hojnacki et al., 2011). This amount of money should be provided in particular designed biogas loans. Second, the interest rate for loans for biogas projects should be 0.5%–1% below the prevailing borrowing rate to further incentive engagement in biogas. Finally, the duration of the biogas loan should be according to the respective project. Like for instance, 10–20 years, which will incentivize more private investment into biogas. Hence, Chinese policy makers should encourage banks to set up these tailored financial criteria for biogas projects to not only simplify the investment into biogas but also improve the reputation of banks as they offer these kinds of products through which they can invest partially themselves.

B. Improving biogas project management by introducing professional guidance (WO strategy): Banks do not possess the resources to conduct an in-depth investment analysis as banks own investment scope is very limited. Hence, the government should encourage banks to improve their relations with biogas experts to increase the risk aware of biogas investments and tremendously reduce internal investment approval processes. Furthermore, cooperating with professionals in the biogas sector will improve the branding of the respective bank and eventually increase its client base.

C. Joint-investment cooperation with private investors (ST strategy): Banks usually have certain investment limitations in place which makes high volume investments in alternative investments like biogas not feasible. Moreover, non-mature markets as biogas increase operating costs. To avoid these aspects and make use of banks valuable reputation, cooperation with other investors should be endorsed by the government for instance through communication channels or other exchange platforms so that operation risks can be reduced. Finally, the non-sufficient level of available funds for biogas project investments will also rise, which makes a joint-investment cooperation very beneficial for banks to overcome the mentioned threats but utilizing its strengths.

D. Establish information channels with investors and biogas experts (WT strategy): Minimizing the weaknesses and threats of banks towards investments into the Chinese biogas sector requires to establish communication channels with other stakeholders. This will not only reduce the limitation of available funds but also reduces a banks operating costs by seeking external advice on biogas investments. These results are illustrated in Fig. 8:

3.2.2. Insurance companies

A. Permitting insurance companies direct investment into biogas equity (SO strategy): In 2010 the China Insurance Regulatory Commission (CIRC) didn't allow any investment of insurance companies in the renewable energy sector as pointed out in the 12th article of the Chinese insurance companies equity investment guidelines (China Insurance Regulatory Commission, 2010). In 2012 the CIRC permitted insurance companies to expand their investments into the renewable energy sector but with strong regulations (China Insurance Regulatory Commission, 2012). Since 2014, the CIRC allows insurance companies to invest in venture capital and private equity funds but with strong limitations, like in chapter 4 (China Insurance Regulatory Commission, 2014). These requirements should be lowered by Chinese policy makers for instance through a

TOWS policy development for Banks	***Internal Strengths (S)*** S1. Existing close relationships with biogas operators (0.196) S2. Localization (0.191) S3. Comparative low capital costs (0.217) S4. Cross-selling opportunity (0.206) S5. Strong branding (0.191)	***Internal Weaknesses (W)*** W1. Investment volume is limited (0.237) W2. High risk/default aversion (0.280) W3. Long investment approval processes (0.256) W4. Investment duration of the biogas project does not match the investment horizon (0.226)
External Opportunities (O) O1. Policy support for investments in biogas (0.278) O2. Public subsidies (0.245) O3. Preferential taxes (0.254) O4. Improves public branding of the organization (0.223)	**Policy to address strengths and opportunities:** 1. Promoting biogas funding products concerning volume, interest rate and duration (s2,s3,o1,o2,o3)	**Policy to address weaknesses and opportunities:** 2. Improving biogas project management by introducing professional guidance (w2,w3,w4,o1,o2,o3)
External Threats (T) T1. Large initial investment required (0.179) T2. Change of policy (0.190) T3. Immature market (0.183) T4. Volume of funds for investments are limited (0.232) T5. High operating costs (0.217)	**Policy to address strengths and threats:** 3. Joint-investment cooperation with private investors (s2,s3,t1,t2,t4,t5)	**Policy to address weaknesses and threats:** 4. Establish information channels with investors and biogas experts (w1,w2,w3,w4,t1,t2,t4,t5)

Fig. 8. Application of TOWS matrix for banks.

lower debt repayment rate as well as lesser requirements on the invested fund volume.

B. Improving government-backed guarantees to reduce operating risks (WO strategy): Being not aware of current trends in the biogas sector and not having the adequate risk assessment tools makes decisions whether an insurance invests into biogas project unlikely. If the government offers certain guarantees like attractive feed-in tariffs to make biogas projects more profitable the anticipated risk for insurances would be reduced by a lot resulting in a higher amount of biogas investment. Furthermore, insurances could leverage their engagement in biogas as a method to attract new customers.

C. Designing a stable and unified biogas tax structure (ST strategy): Currently, the taxes paid by biogas operators are based on the respective agreements with the local government. This causes a lot of insecurity for insurances which want to invest into biogas projects as a high tax could drastically diminish the returns. Hence, by providing a stable nation-wide tax for all biogas projects, Chinese policy makers would make biogas projects, a more stable and attractive investment choice.

D. Encouraging market mechanisms in the biogas sector (WT strategy): The Chinese biogas market is still in an infant stage and has a tremendous growth potential. Nevertheless, it is crucial for insurance companies to have a sound knowledge of the biogas sector before engaging in investment activities. Furthermore, the most important threat for insurance companies is that they are not able to conduct adequate risk assessments. Hence, if the government would push for more market-mechanisms, it would be easier for insurances to get an understanding of the biogas sector and therefore, increase investments. These policy results are demonstrated in Fig. 9.

3.2.3. Pension funds

A. Permitting pension funds direct investment into biogas equity (SO strategy): Same as insurance companies, pension funds are allowed to directly invest in biogas equity but with strong limitations (China's State Council, 2015). Currently, they rather invest through private equity funds into biogas projects. Hence, allowing pension funds to conduct direct equity investments into biogas plants with fewer restrictions would ultimately boost pension fund's investment into biogas.

B. Improving government-backed guarantees to reduce operating risks (WO strategy): Pension funds usually are very risk avers, which in particular for immature markets like biogas in China demonstrates a serious investment obstacle. Hence, if Chinese policy makers would increase certain guarantees, like feed-in tariffs or guaranteeing a certain rate of return, pension funds investments in this sector would be boosted.

C. Designing a stable and unified biogas tax structure (ST strategy): Pension funds similar to insurance companies promoted a stable und unified biogas tax for China as the current system with different tax rates varying from province to province makes investments into biogas projects less attractive. If Chinese policy makers could design and implement a unified tax for biogas operations, investors like pension funds can simplify their return calculation and have more incentives to invest into biogas. Furthermore, a unified tax rate reduces operational and financial risks due to guaranteeing a stable environment for pension funds in the biogas sector.

D. Encouraging market mechanisms in the biogas sector (WT strategy): Like insurance companies, pension funds also require stable conditions in the Chinese biogas sector. Market-mechanisms are required by pension funds as they guarantee efficient operations within a biogas plant as well as competitive price adjustments to reduce financial risks. By promoting market mechanisms in the biogas sector, private investors will be incentivized to raise their investments in that sector. These results are shown in Fig. 10:

3.2.4. PE funds

A. Creating an efficient national platform for biogas investment (SO strategy): Private equity funds have high volumes of funds available to invest. Furthermore, they have managerial expertise as well as good contacts to biogas experts as well as policy makers. Being willing to take a higher risk in their investments, provides them with an advantage over other investors in particular if it comes to biogas projects. To further promote private equity investments in

TOWS policy development for Insurance companies	***Internal Strengths (S)*** S1. Long investment duration (0.251) S2. Seeking alternative investment sources for their funds (0.208) S3. Stable amount of money to invest (0.299) S4. Expected return comparatively low (0.243)	***Internal Weaknesses (W)*** W1. High risk/default aversion (0.215) W2. Not sufficient research capabilities on new assets (0.293) W3. Scale (0.241) W4. Long investment approval processes (0.251)
External Opportunities (O) O1. Policy support for investments in biogas (0.170) O2. Public subsidies (0.197) O3. Sufficient liquidity to not be dependent on short term market turbulences (0.243) O4. Improves public branding (0.212) O5. Preferential taxes (0.178)	**Policy to address strengths and opportunities:** 1. Permitting insurance companies direct investment into biogas equity (s1,s2,s3,o1,o2,o3,o5)	**Policy to address weaknesses and opportunities:** 2. Improving government-backed guarantees to reduce operating risks (w1,w2,w3,w4,o1,o2,o3)
External Threats (T) T1. Low proficiency in the evaluation of risks (0.354) T2. Immature market (0.342) T3. Change of policy (0.304)	**Policy to address strengths and threats:** 3. Designing a stable and unified biogas tax structure (s1, s2, s3, t1, t2, t3)	**Policy to address weaknesses and threats:** 4. Encouraging market mechanisms in the biogas sector (w1,w2,w3,w4,t1,t2,t3)

Fig. 9. Application of TOWS matrix for insurance companies.

TOWS policy development for Pension funds	***Internal Strengths (S)*** S1. Long investment duration (0.246) S2. Expected return comparatively low (0.228) S3. Stable amount of money to invest (0.298) S4. Seeking alternative investment sources for their funds (0.228)	***Internal Weaknesses (W)*** W1. Lack of identifying investment opportunities (0.213) W2. High risk/default aversion (0.261) W3. Not sufficient research capabilities on new assets (0.287) W4. Scale (0.238)
External Opportunities (O) O1. Policy support for investments in biogas (0.182) O2. Public subsidies (0.174) O3. Improves public branding of the organization (0.217) O4. Sufficient liquidity to not be dependent on short term market turbulences (0.254) O5. Preferential taxes (0.173)	**Policy to address strengths and opportunities:** 1. Permitting pension funds to directly invest into biogas equity (s1,s2,s3,s4,o1,o2,o3,o5)	**Policy to address weaknesses and opportunities:** 2. Improving government-backed guarantees to reduce operating risks (w1,w2,w3,w4,o1,o2,o3)
External Threats (T) T1. Low proficiency in the evaluation of risks (0.364) T2. Immature market (0.330) T3. Change of policy (0.306)	**Policy to address strengths and threats:** 3. Designing a stable and unified biogas tax structure (s1,s2,s3,t1,t2,t3)	**Policy to address weaknesses and threats:** 4. Encouraging biogas usage and creating a nation-wide market (w1,w2,w3,w4,t1,t2,t3)

Fig. 10. Application of TOWS matrix for pension funds.

biogas, Chinese policy makers should promote the establishment of a national platform for biogas investments to share macro economic information like for instance industry maturity and policy status. In addition to that, information on past project performance should be shared, which can serve as a benchmark for future investments.

B. Providing early exit possibilities and promoting VAM (WO strategy): The major weakness for private equity funds is that they usually aim for a short investment period. As biogas projects are long-term investment projects and due to the fact the break-even point is achieved only after some years, Chinese policy makers should provide different business model strategies for private equity investors to ensure the participation in the biogas sector. This would not only result in a higher amount of investment but also into more efficient operation processes in the biogas sector, involving management expertise, operation efficiency, and financial efficiency. Finally, the promotion of valuation adjustment mechanisms will add further incentives for private equity funds to invest in biogas projects (Ma et al., 2013).

C. Designing a stable and unified biogas tax structure (ST strategy): Private equity funds are requiring stable conditions so that they can calculate their expected return. A unified and stable biogas nation wide would be a great step forward to further incentivize private equity investment into biogas.

D. Encourage public-private partnerships (WT strategy): Large investment costs which reduce the return of the biogas investment are the major threat for private equity funds. To reduce this obstacle, Chinese policy makers should encourage public, private partnerships to share the initial investment costs of the biogas plant project. This would also enable to match the high return requirements of private equity funds. These results are illustrated in Fig. 11:

3.2.5. High network individuals

A. Information campaigns to encourage HNI to invest in biogas projects (SO strategy): The number of high network individuals in China has constantly been rising through the past years. The available funds they possess can be the valuable source for investments into biogas. Nevertheless, most HNI are not aware of biogas projects. Chinese policy makers are therefore encouraged to initiate information campaigns to raise the awareness of this investment class.

B. Improving project cooperation by introducing professional guidance (WO strategy): As HNI have the financial resources but mostly are not familiar with the biogas sector, improving cooperation with biogas specific experts in terms of funding, construction, operation management, human resources, marketing as well as supervision would increase the attractiveness of biogas projects for HNI.

C. Providing a platform to find the adequate institution to consult or cooperate with (ST strategy): HNI lack the proficiency to evaluate risks appropriately as their resources are in comparison to other financial institutions very limited. Hence, Chinese policy makers are encouraged to provide the platform to connect HNI with institutions, which have for instance advanced resources to design sound biogas project analysis.

D. Providing consultancy services as well as offering the appropriate scale of biogas projects (WT strategy): HNI possess plenty of financial resources. Nevertheless, in most cases the resources are not enough to fund a large-scale biogas project by themselves as the risk for that particular investment is extremely high. Hence, Chinese policy makers should encourage consultancy on joint-investment cooperation as well as provide certain scales of biogas projects, which suit the requirement of HNI. This is demonstrated in Fig. 12:

3.2.6. Ranking of the developed TOWS strategies

The next step of the analysis was to conduct expert interviews to rank and therefore prioritize each of the four strategies developed from the TOWS matrix. This was done face to face expert interviews including five interviewees per stakeholder group. The results are demonstrated in Table 10:

According to the face to face expert interviews, banks ranked the promotion of biogas financial products in terms of volume, interest rate and duration as the most important strategy based on the TOWS matrix. Insurance companies and pension funds ranked the

TOWS policy development for PE funds	***Internal Strengths (S)***	***Internal Weaknesses (W)***
	S1. High volume of funds available (0.213) S2. Access to expertise in the particular sector of investment (0.138) S3. Access to management expertise (0.144) S4. Interested in new investment fields (0.119) S5. Access to policy makers (0.174) S6. Access to biogas market participants (0.212)	W1. Restrictive provisions (0.158) W2. Usually, prefer an IPO exit (0.251) W3. Investment horizon is very short (0.175) W4. High return requirements (0.223) W5. Usually, do not prefer investments with high initial costs (0.193)
External Opportunities (O) O1. First mover advantage (0.141) O2. Policy support for investments in biogas (0.152) O3. Preferential taxes (0.169) O4. Create profitable partnerships with the best biogas experts (0.215) O5. Public subsidies (0.191) O6. High volume of funds available (0.131)	**Policy to address strengths and opportunities:** 1. Creating an efficient national platform for biogas investment (s1,s2,s3,s4,o1,o2,o3,o4,o5,o6)	**Policy to address weaknesses and opportunities:** 2. Providing early exit possibilities and protecting VAM (w1,w2,w3,w4,o1,o2,o3)
External Threats (T) T1. Large initial investment costs (0.287) T2. Immature market (0.234) T3. Change of policy (0.218) T4. High operating costs (0.262)	**Policy to address strengths and threats:** 3. Designing a stable and unified biogas tax structure (s5,s6,t1,t2,t3)	**Policy to address weaknesses and threats:** 4. Encourage public-private partnerships (w5,,t1,t2,t3,t4)

Fig. 11. Application of TOWS matrix for PE funds.

TOWS policy development for High network individuals	***Internal Strengths (S)***	***Internal Weaknesses (W)***
	S1. High-risk tolerance (0.228) S2. Personal preference-based investment decisions (0.198) S3. Strong network (0.184) S4. Fast decision making (0.195) S5. Willing to promote renewable energy (0.194)	W1. Lack of identifying investment opportunities (0.326) W2. Not sufficient research capabilities on new assets (0.355) W3. Scale (0.319)
External Opportunities (O) O1. Policy support for investments in biogas (0.244) O2. Public subsidies (0.177) O3. Preferential taxes (0.177) O4. Personal preference-based investment decisions (0.213) O5. Level of return not as important as the desire to boost clean energy (0.190)	**Policy to address strengths and opportunities:** 1. Promoting biogas funding products concerning volume, interest rate and duration (s2,s3,o1,o2,o3)	**Policy to address weaknesses and opportunities:** 2. Improving biogas project management by introducing professional guidance (w2,w3,w4,o1,o2,o3)
External Threats (T) T1. Volume of funds for investments are limited (0.164) T2. Low proficiency in the evaluation of risks (0.233) T3. Immature market (0.196) T4. Large initial investment costs (0.228) T5. Change of policy (0.178)	**Policy to address strengths and threats:** 3. Joint-investment cooperation with private investors (s2,s3,t1,t2,t4,t5)	**Policy to address weaknesses and threats:** 4. Establish information channels with investors and biogas experts (w1,w2,w3,w4,t1,t2,t4,t5)

Fig. 12. Application of TOWS matrix for HNI's.

possibility to directly invest into biogas equity as the most crucial option based on the TOWS analysis. PE funds indicated that for them, the encouragement of private-public partnerships would be the most important factor to increase their engagement in the Chinese biogas sector. Finally, high network individuals endorse the improvement of project cooperation by introducing professional guidance on biogas investments to maximize their engagement in that sector.

The feasibility of these strategies was also an important aspect of the face to face interviews and have been included into the prioritization. For instance, direct equity investments are currently partially prohibited due to the high risk. Nevertheless, the volume of funds of insurance companies as well as of pension funds is very high, which would allow a certain level of investment into high risk assets. Nevertheless, the specific level can be decided by the policy makers and hasn't been analyzed in this study.

4. Discussion

This paper conducted a private investor investment preference analysis of the biogas sector in China due to the fact that the Chinese government intends to attract private investment into the

Table 10
Expert interviewees ranking on TOWS strategies based on stakeholder groups.

Strategy based on stakeholder group	Mean	SD
Banks		
1. Promoting biogas funding products concerning volume, interest rate, and duration	**8.6**	**3.35**
2. Improving biogas project management by introducing professional guidance	7	2.00
3. Joint-investment cooperation with private investors	8	1.41
4. Establish information channels with investors and biogas experts	6.6	1.79
Insurance companies		
1. Permitting insurance companies direct investment into biogas equity	**9.6**	**1.10**
2. Improving government-backed guarantees to reduce operating risks	8.6	1.79
3. Designing a stable and unified biogas tax structure	7.4	3.03
4. Encouraging market mechanisms in the biogas sector	8	2.00
Pension funds		
1. Permitting pension funds to directly invest in biogas equity	**9.2**	**0.89**
2. Improving government-backed guarantees to reduce operating risks	8.4	1.10
3. Designing a stable and unified biogas tax structure	7.6	1.79
4. Encouraging biogas usage and creating a nation-wide market	8.2	0.89
PE funds		
1. Creating an efficient national platform for biogas investment	8.4	1.10
2. Providing early exit possibilities and protecting VAM	7	2.45
3. Designing a stable and unified biogas tax structure	8.6	1.79
4. Encourage public-private partnerships	**9.6**	**1.10**
HNI		
1. Information campaigns to encourage HNI to invest in biogas projects	9	1.41
2. Improving project cooperation by introducing professional guidance	**10**	**0.00**
3. Providing a platform to find the adequate institution to consult or cooperate with	8.4	1.10
4. Providing consultancy services as well as offering the appropriate scale of biogas projects	7.8	2.61

The bold numbers indicate the most significant factor's share of supports received from the interviews.

renewable energy sector and yet is not aware of private stakeholder's investment preferences. First, we determined the investment preferences of private investors through a SWOT analysis and based on an AHP method identified the priorities of private investors towards these preferences. Finally, we conducted a TOWS analysis based on expert interviews to develop private investment strategies for Chinese policy makers.

According to the SWOT-AHP analysis, banks have low capital costs as a major strength, as they can refinance based on the prevailing deposit rate, which makes investments into biogas very lucrative. Also the high priority of the increase of public branding for the bank when investing into biogas. This illustrates that not only financial results are important for this stakeholder group. Nevertheless, the biggest weakness and threat are respectively their risk aversion as well as the non-sufficient amount of funds they possess, which makes investments into large-scale biogas projects unlikely unless there is cooperation among private investors. Insurance companies and pension funds have very similar investment preferences as well as similar priorities. Both stakeholder groups key strengths and opportunities are the stable amount of funds they have for investment as well as non-dependency on short-term liquidity, which is ideal for investment into biogas. Private equity funds key strengths are the high volume of funds as well as the connections they possess. Nevertheless, the high initial investment costs make it unattractive for them to invest into biogas. Finally, HNI conduct their investment decisions based on individual preferences and in some cases care about the promotion of biogas rather than their financial gain but lack the scale of funds, which are required for large-scale biogas projects.

The TOWS analysis concluded that among banks, (1) Promoting financial tailored biogas products in terms of volume, interest rate and duration for banks is the preferred policy. (2) Allowing insurance companies and pension funds to conduct direct investments into biogas equity. (3) Encouraging public, private partnerships for PE funds, to reduce the initial amount of investments. (4) Improving project cooperation for HNI's by introducing professional guidance concerning funding, construction, management, human resources, marketing and supervision to simplify investments into biogas projects.

Based on these research results, the previous mentioned obstacles in the literature review, for instance, the lack of private funding as well as the non-awareness of private investors investment preferences for biogas in China, can be overcome. In fact, these research results, provide a concise framework for Chinese policy makers to attract private investment and reduce government spending.

The SWOT-AHP-TOWS methodology is a very renowned and effective analysis tool but also has certain limitations like for instance being subjective and biased to a certain degree (The World Bank, 2002; World Wide Fund, 2005). To reduce these two aspects, we chose a rather large sample size and conducted expert interviews to achieve as much as possible objective and unbiased private investment strategies for the Chinese biogas.

5. Conclusion

China is actively promoting the expansion of biogas and intends to produce 44 Giga cubic meter of biogas by 2020. To achieve this goal, the Chinese government plans to attract private investments into the biogas sector. Nevertheless, there have been no studies in academic literature, which deal with this particular issue. To close this gap, this study conducts an SWOT-AHP-TOWS analysis to identify private investor stakeholder's investment preferences based on SWOT factors, measure the priority of each factor and develop private investment strategies for the Chinese biogas sector based on a TOWS matrix.

Banks have low capital costs but lack the volume of funds necessary for investment. Insurance companies as well as pension funds both have sufficient funds and can invest them for the respective duration of a biogas project but also both lack the ability to conduct an appropriate risk analysis on the biogas sector. Private equity funds have required resources and network but high tremendously high return expectation as well as short investment horizon which doesn't match with the duration of biogas projects.

Finally, HNI's have fast investment decision-making processes but lack a sound understanding of the Chinese biogas sector.

The most important identified private investment strategies of each stakeholder for the Chinese biogas sector are: (1) Promoting financial tailored biogas products in terms of volume, interest rate and duration for banks; (2) Permitting insurance companies and pension funds direct investment into biogas equity; (3) Encouraging people private partnerships and (4) Improving project cooperation by introducing professional guidance. By implementing these strategies, private investment into biogas can be boosted.

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Appendix

Factor/AHP	Issue
A. SWOT factors for banks	
Strengths (S)	
S1 (0.196)	Existing close relationships with biogas operators (obtaining knowledge on the biogas sector)
S2 (0.191)	Localization (availability if problems arise due to dense network)
S3(**0.217**)	Comparative low capital costs (due to the low deposit interest rate)
S4 (0.206)	Cross-selling opportunity (offer other financial products to optimize financial situation of a biogas project)
S5 (0.191)	Strong branding (more easy to find other investors due to a banks engagement in the biogas project)
Weaknesses (W)	
W1 (0.237)	Investment volume is limited (due to high volume required by a biogas project)
W2(**0.280**)	High risk/default aversion (Risk attitude towards the biogas project)
W3 (0.256)	Long investment approval processes (decision-making is slow)
W4 (0.226)	Investment duration of the biogas project may not match with the investment horizon of the bank
Opportunities (O)	
O1 (**0.278**)	Policy support for investments in biogas (Policy goals of the government serve as an incentive to invest)
O2 (0.245)	Public subsidies (Feed-in tariffs guarantee stable and plannable cash flows)
O3 (0.254)	Preferential taxes (increase returns due to fewer taxes on the income)
O4 (0.223)	Improves public branding of the organization (obtain new clients due to renewable energy investments)
Threats (T)	
T1 (0.179)	Large initial investment required (due to the size of the biogas project)
T2 (0.190)	Change of policy (the risk that the government reduces its policy goals and cuts, for instance, feed-in tariffs)
T3 (0.183)	Immature market (customers prefer more familiar investments areas than biogas)
T4(**0.232**)	Volume of funds for investments are limited (the respective institution is not able to raise the necessary amount of funding)
T5 (0.217)	High operating costs (project specific operating costs may be extremely high)
B. SWOT factors for insurance companies	
Strengths (S)	
S1 (0.251)	Long investment duration (matching the respective biogas projects characteristics)
S2 (0.208)	Seeking alternative investment sources for their funds (as the yields of government bonds might not be sufficient)
S3(**0.299**)	Stable amount of money to invest (receive a high amount of deposits from their clients for a long duration)
S4 (0.243)	Expected return comparatively low (expected return is in comparison to other private investors low)
Weaknesses (W)	
W1 (0.215)	High risk/default aversion (Risk attitude towards the biogas project)
W2(**0.293**)	Not sufficient research capabilities on new assets (usually require positive benchmark investment)
W3 (0.241)	Scale (investment ticket of the respective biogas project must be big to justify costs)
W4 (0.251)	Long investment approval processes (decision-making is slow)
Opportunities (O)	
O1 (0.170)	Policy support for investments in biogas (Policy goals of the government serve as an incentive to invest)
O2 (0.197)	Public subsidies (Feed-in tariffs guarantee stable and plannable cash flows)
O3(**0.243**)	Sufficient liquidity to not be dependent on short term market turbulences
O4 (0.212)	Improves public branding of the organization (obtain new clients due to renewable energy investments)
O5 (0.178)	Preferential taxes (increase returns due to fewer taxes on the income)
Threats (T)	
T1(**0.354**)	Low proficiency in the evaluation of risks (due to lack of appropriate resources)
T2 (0.342)	Immature market (customers prefer more familiar investments areas than biogas)
T3 (0.304)	Change of policy (the risk that the government reduces its policy goals and cuts, for instance, feed-in tariffs)
C. SWOT factors for pension funds	
Strengths (S)	
S1 (0.246)	Long investment duration (matching the respective biogas projects characteristics)
S2 (0.228)	Expected return comparatively low (expected return is in comparison to other private investors low)
S3(**0.298**)	Stable amount of money to invest (receive a high amount of deposits from their clients for a long duration)
S4 (0.228)	Seeking alternative investment sources for their funds (as the yields of government bonds might not be sufficient)

(*continued*)

Factor/AHP	Issue
Weaknesses (W)	
W1 (0.213)	Lack of identifying investment opportunities (due to a lack of resources for non-standard investment assets like biogas)
W2 (0.261)	High risk/default aversion (risk attitude towards the biogas project)
W3**(0.287)**	Not sufficient research capabilities on new assets (usually require positive benchmark investment)
W4 (0.238)	Scale (investment ticket of the respective biogas project must be big to justify costs)
Opportunities (O)	
O1 (0.182)	Policy support for investments in biogas (Policy goals of the government serve as an incentive to invest)
O2 (0.174)	Public subsidies (Feed-in tariffs guarantee stable and plannable cash flows)
O3 (0.217)	Improves public branding of the organization (obtain new clients due to renewable energy investments)
O4**(0.254)**	Sufficient liquidity to not be dependent on short term market turbulences
O5 (0.173)	Preferential taxes (increase returns due to fewer taxes on the income)
Threats (T)	
T1**(0.364)**	Low proficiency in the evaluation of risks (due to lack of appropriate resources)
T2 (0.330)	Immature market (customers prefer more familiar investments areas than biogas)
T3 (0.306)	Change of policy (the risk that the government reduces its policy goals and cuts, for instance, feed-in tariffs)
D. SWOT factors for PE funds	
Strengths (S)	
S1**(0.213)**	High volume of funds available (due to the accumulation of various other investor's funds)
S2 (0.138)	Access to expertise in the particular sector of investment (can adequately identify investment risks)
S3 (0.144)	Access to management expertise (make processes in the biogas plant more effective)
S4 (0.119)	Interested in new investment fields (first mover advantage)
S5 (0.174)	Access to policy makers (strong network of PE funds to be aware of prevailing biogas policies)
S6 (0.212)	Access to biogas market participants (strong network enables detailed insights into the biogas sector)
Weaknesses (W)	
W1 (0.158)	Restrictive provisions (investment range is limited due to legal regulations on PE funds)
W2**(0.251)**	Usually, prefer an IPO exit (exit strategy problem for PE funds)
W3 (0.175)	Investment horizon is very short (while the duration of a biogas project as is usually for more then ten years)
W4 (0.223)	High return requirements (usually between 20% and 30%)
W5 (0.193)	Usually, do not prefer investments with high initial costs (like biogas projects with high construction costs)
Opportunities (O)	
O1 (0.141)	First mover advantage (make business processes more efficient)
O2 (0.152)	Policy support for investments in biogas (Policy goals of the government serve as an incentive to invest)
O3 (0.169)	Preferential taxes (increase returns due to fewer taxes on the income)
O4**(0.215)**	Create profitable partnerships with the best biogas experts (willingness to cooperate with PE funds)
O5 (0.191)	Public subsidies (Feed-in tariffs guarantee stable and plannable cash flows)
O6 (0.131)	High volume of funds available (due to the accumulation of various other investor's funds)
Threats (T)	
T1**(0.287)**	Large initial investment costs (for instance construction costs of the biogas plants
T2 (0.234)	Immature market (prefer more familiar investments areas than biogas)
T3 (0.218)	Change of policy (the risk that the government reduces its policy goals and cuts, for instance, feed-in tariffs)
T4 (0.262)	High operating costs (project specific operating costs may be extremely high)
E. SWOT factors for HNI's	
Strengths (S)	
S1**(0.228)**	High-risk tolerance (HNI are in some cases more willing to take risks than institutional investors)
S2 (0.198)	Personal preference-based investment decisions (decision whether to invest in biogas project is based on individual preferences)
S3 (0.184)	Strong network (with policy makers, other investors and eventually experts in the biogas sector)
S4 (0.195)	Fast decision making (as an HNI does not need to approval of other partners)
S5 (0.194)	Willing to promote renewable energy (in some cases, regardless of the return expectations)
Weaknesses (W)	
W1 (0.326)	Lack of identifying investment opportunities (due to a lack of resources of an individual investor)
W2**(0.355)**	Not sufficient research capabilities on new assets (usually require positive benchmark investment)
W3 (0.319)	Scale (investment ticket of the respective biogas project must be big to justify costs)
Opportunities (O)	
O1**(0.244)**	Policy support for investments in biogas (Policy goals of the government serve as an incentive to invest)
O2 (0.177)	Public subsidies (Feed-in tariffs guarantee stable and plannable cash flows)
O3 (0.177)	Preferential taxes (increase returns due to fewer taxes on the income)
O4 (0.213)	Personal preference-based investment decisions (decision whether to invest in biogas project is based on individual preferences)
O5 (0.190)	Level of return not as important as the desire to boost clean energy (regardless of return expectations of the particular biogas project)
Threats (T)	
T1 (0.164)	Volume of funds for investments are limited (usually an individual can not invest as much as an institution into a biogas project)
T2**(0.233)**	Low proficiency in the evaluation of risks (due to lack of appropriate resources)
T3 (0.196)	Immature market (customers prefer more familiar investments areas than biogas)
T4 (0.228)	Large initial investment costs (for instance construction costs of the biogas plants
T5 (0.178)	Change of policy (the risk that the government reduces its policy goals and cuts, for instance, feed-in tariffs)

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